CANADIANA
APR 15 1981

CANADA
DEPARTMENT OF MINES
HON. MARTIN BURRELL, MINISTER; R. G. MCCONNELL, DEPUTY MINISTER.

MINES BRANCH
EUGENE HAANEL, PH.D., DIRECTOR.

BULLETIN No. 29

Potash Recovery at Cement Plants

BY

Alfred W. G. Wilson, Ph.D.
Special Investigator for the War Trade Board

OTTAWA
J. DE LABROQUERIE TACHÉ
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1919

No. 507

CANADA
DEPARTMENT OF MINES
HON. MARTIN BURRELL, MINISTER; R. G. MCCONNELL, DEPUTY MINISTER.

MINES BRANCH
EUGENE HAANEL, PH.D., DIRECTOR.

BULLETIN No. 29

Potash Recovery at Cement Plants

BY

Alfred W. G. Wilson, Ph.D.
Special Investigator for the War Trade Board

OTTAWA
J. DE LABROQUERIE TACHÉ
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1919

No. 507

62342—1

LETTER OF TRANSMITTAL.

JOHN MCLEISH, ESQ., B.A.,
Acting Director Mines Branch,
Department of Mines,
Ottawa.

SIR,—I submit, herewith, a general report on Potash Recovery at Cement Plants. The investigations upon which the report is based were made under the auspices of the War Trade Board. The information gathered is of commercial interest to many persons in Canada, hence it appears desirable to render it accessible to all who require it, and to preserve it as a permanent record of the investigation. I therefore recommend that the report be issued as a Bulletin by the Mines Branch.

I have the honour to be, Sir,
Your obedient servant,
(Signed) **Alfred W. G. Wilson.**

OTTAWA, May 6, 1919.

CONTENTS.

PAGE
Introductory 7
Historical review 10
Notes on the chemistry of the process 12
Cement mill dust recovery 14
    General 14
    Dry cleaning methods 15
        Expansion chamber system 15
        Electrical precipitation 15
        Water film treater 16
    Spray systems 17
        General 17
        Supplementary operations 18
    Descriptions of installations 19
        Riverside Portland Cement Company 19
        Alpha Portland Cement Company 20
        Dexter Portland Cement Company 20
        Security Cement and Lime Company 20
        Newaygo Portland Cement Company 21
        Golden State Portland Cement Company 22
        Southwestern Portland Cement Company 22
        Portland Cement Company of Utah 23
        Ogden Portland Cement Company 23
        Santa Cruz Portland Cement Company 24
Conditions in Canada 24
Future market prices 28
Alsatian Potash Prices 29
Protection for potash producers in the United States 29
Cost of potash recovery 30
    Equipment costs 30
    Operating costs 30
Conclusions 31
Bibliography 32

TABLES.

I. Imports of potash salts 9
II. Cement plants provided with potash recovery equipment 12
III. Cement mills in Canada 25
IV. Potash content of cement mill materials 26

ILLUSTRATIONS.

Photographs.

Plate I. Electrical treater: reinforced concrete construction. Dexter Portland Cement Co., Nazareth, Pennsylvania End
II. Electrical treater—double flue and breechings. Dexter Portland Cement Co., Nazareth, Pennsylvania "
III. Pipe type dry electrical treater. Riverside Portland Cement Co., Riverside, California "
IV. Treater building and stacks: reinforced concrete construction. Newaygo Portland Cement Co., Newaygo, Michigan "
V. Treating plant, employing spray system: reinforced concrete construction. Ogden Portland Cement Co., Bakers, Utah "
VI. Treating plant, saturator: tile block construction. Ogden Portland Cement Co., Bakers, Utah "
VII. Spray treater and condenser: reinforced concrete construction. Southwestern Portland Cement Co., Ltd., Victorville, California "
VIII. Spray treater. Golden State Portland Cement Co., Oro Grande, California "
IX. Reinforced concrete sub-structure below saturator, showing bottom of trough in which circulating liquors are collected. Portland Cement Co. of Utah, Salt Lake City, Utah "
X. Sub-structure of saturator: concrete columns and beams. Portland Cement Co. of Utah, Salt Lake City, Utah "

POTASH RECOVERY AT CEMENT PLANTS.

INTRODUCTORY.

The investigations upon which this bulletin is based were undertaken under instructions from the Chairman of the Committee of Reconstruction and Development, and the War Trade Board. Their purpose was to have available, in Ottawa, the most recent information with respect to the progress that has been made in the development of successful processes for recovering potash from flue dust in a form suitable for industrial purposes.

Potash salts have not been produced in Canada on a commercial scale. We are now saving or producing a small amount of potash-bearing materials which are being utilized in the fertilizer industry, but the total amount available is not equal to our own needs. Prior to the war we imported all the compounds of potash required by our industries, chiefly from Germany, minor importations coming from Great Britain and the United States. Both these countries, however, and nearly all other countries of the world, also derived their principal supplies of the primary salts from Germany.

The average annual cash value of *all* potash salts imported during the five-year period 1910 to 1914 (ending March 31), on the basis of import data published by the Department of Customs, was $503,702. This includes an amount of $155,243 given as the import value of certain potash salts which are used chiefly in the fertilizer industry for food production. The other salts imported were utilized by other Canadian industries, chiefly in the recovery of gold and silver, in glass making, in tanning, and in certain chemical manufacturing processes, including soaps.

The total weight of potash salts available for fertilizers averaged 8,773,664 pounds, during each year of the five-year period prior to the war. The classification adopted by the Department of Customs fails to take cognizance of the market basis on which these salts are sold, and it is impossible to estimate the actual potash content of the various salts imported. These are all lumped together in the published statistics, regardless of composition or of commercial value. It is probable that Canada at present consumes only about 1,200 tons of potash (K_2O) per annum, in fertilizers.

Corresponding weights and values of importations for the four years of the war are shown in Table I on page 9. The decline in quantity as well as value, together with the increase in unit value, is most marked.

It is unnecessary to discuss, in this report, the importance of suitable potash salts for utilization in manufacturing mixed fertilizers. Food production not only cannot be maintained, but it will show a very marked decline if these salts are not available as plant food. In the future, in addition to other constituents of plant foods, we are going to require much larger quantities of potash salts to maintain grain production in the West. The rapid decline in the acre yield of many areas in Manitoba is due, largely, to the removal and export—over a term of years—of important soil chemicals, chiefly potash salts and phosphates, and to the failure to replace these losses. In brief, it may be stated that potash salts are absolutely essential to food production, and an independent home source of supply seems desirable in the national interest.

At the present time fifteen cement plants in the United States have installed, or are installing potash recovery equipment. In those plants where the equipment was installed two years or more ago, their principal business during the last year of the war was potash recovery, the cement produced being rather of the nature of a by-product. Several plants paid for their entire installation within the first year of operating, and many of them appear confident of their ability to continue in operation under normal conditions.

The total output of all potash materials in the United States, in 1917, was 126,577 short tons, which contained 32,366 tons of pure potash (K_2O) or 26·4 per cent. This was more than three times the production in the previous year. The production in 1918 has been almost 53,000 tons of pure potash. The total requirements of the United States are said to be about 240,000 tons.

In 1917, about 45 per cent of the total production of potash was derived from brines; about 10 per cent from kelp; nearly 9 per cent from charred molasses residues; and about 5 per cent from cement mills. Cement mill production of potash in 1918 was equivalent to 1,429 tons of pure potassium oxide.

In Canada, there are two important potential sources of potash supply—the cement mills and the blast furnaces. The latter source has not yet been investigated, although one steel plant reports a high potash content in the dust from the stoves. In the United States three steel plants are said to be recovering potash from their flue gases, experimentally. It is reported that in England a large quantity is being recovered from blast furnace gases, and that eventually this will probably be sufficient to provide for home requirements at least.[1]

---

[1] Compare with the Board of Trade Journal, London, Sept.5, 1918, p. 303.

TABLE I.

Imports of Potash Salts.

(Fiscal Year ends March 31.)

Fiscal Year	Caustic (Packages over 25 lbs.)		Chloride (Ground).		Bichromate. (Crude).		(Chloride and Sulphate (Crude)	
	Pounds.	Value, $	Pounds	Value, $	Pounds.	Value, $	Pounds.	Value, $
Average for 5 years.	450,546	23,644	694,755	50,717	384,522	26,372	8,117,994	150,750
1915 . .	501,394	36,451	808,685	70,195	102,750	8,608	7,485,715	146,061
1916 . . .	83,834	22,747	70,266	12,079	127,793	17,023	1,133,182	41,413
1917....	23,797	16,423	14,918	8,813	37,631	15,777	700,947	83,255
1918	3,341	1,920	126	95	12	11	485	578

Fiscal Year.	Prussiate (Red and yellow).		Pearl ash. Packages over 25 lbs.)		Kainite and manure salts.		Nitrate	
	Pounds.	Value $	Pounds.	Value $	Pounds.	Value, $	Pounds.	Value, $
Average for 5 years,	159,413	15,588	352,576	10,697	655,670	4,493	1,929,747	88,873
1915 .	134,760	22,351	62,518	6,226	760,902	13,370	2,308,377	142,639
1916 .	112,761	56,571	100,943	17,334	96,450	2,358	1,845,266	262,015
1917	52,177	36,263	13,537	4,759	383,505	7,979	610,085	90,874
1918.	160	293	180	225	60,000	4,931	123,198	22,613

Fiscal Year.	Cyanide		Bicarbonate.		Pearl ash. (Packages less than 25 lbs.)		Caustic (Packages less than 25 lbs.)	
	Pounds	Value, $	Pounds.	Value, $	Pounds.	Value, $	Pounds.	Value, $
Average for 5 years	836,240	129,356	16,276	324	22,469	1,196	31,585	1,692
1915 .	1,862,860	331,530	3,688	385	4,022	150	19,467	1,379
1916	2,116,618	407,313	3,276	429	6,358	484	5,828	759
1917	2,614,050	549,359	1,881	480	17,063	1,863	12,116	1,159
1918 . .	206,370	55,030	50	46	5	10	40	64

On another page will be found a complete list showing the names of all manufacturers of portland cement, in whose plants potash recovery equipment is known to have been installed, or to be in course of installation in December, 1918. Mr. Shirley Barr, an engineer in the employ of the Canada Cement Company, Montreal, and the writer, were privileged to inspect, in detail, twelve out of the fifteen installations in the United States. The three plants omitted were under construction, and the equipment for the most part duplicates that seen elsewhere.

The Mines Branch of the Department of Mines is under great obligation to the management and chief technical officers of the various plants visited in the United States for the facilities afforded us. The writer wishes publicly to acknowledge his indebtedness to these gentlemen, and to thank them for the uniform courtesy with which we were received, and for the frankness with which our inquiries were answered.

It is obvious that much of the equipment at present in use, and portions of the processes now employed in the recovery of potash from cement mill stack gases, are development of new ideas, or new adaptations of old processes. Some of these new ideas have been protected by patents, others have not. Since much of the information available is at present private property, it is not possible to present complete descriptions and plans of the several installations now in operation. Only brief descriptive statements can be given in this report. Where descriptive articles have been published, references are given. Where more information is required than is given here, the reader is referred to the management of the operating company concerned.

It has been possible to introduce a number of halftone illustrations showing the types of construction in use at typical plants.

As this report is going to press, information has been received from the Canada Cement Company, to the effect that they are preparing plans for a potash recovery installation at their Port Colborne, Ontario, plant. This will be the first installation of its kind in Canada.

HISTORICAL REVIEW.

It has long been known that small quantities of silicates of the alkaline metals were present in the raw mixture used for the manufacture of portland cement. The first reference to the occurrence of soluble material containing alkalies in the dust of a cement plant which has come to the writer's attention, was by Seger and Cramer in 1904.[1]

They found that dust from a cement works consisted of 43·65 per cent of insoluble and 56·35 per cent of soluble material. The soluble portion was found to consist of 61·1 per cent potassium sulphate and 3·89 per cent potassium carbonate.

R. H. Meade[2] states that the possibility of recovering potash as a by-product in the portland cement industry was first pointed out by Dr. Clifford Richardson at a meeting of the American Society for Testing Materials at Atlantic City, in June, 1904. At that time Dr. Richardson calculated that in a cement plant turning out 4,000 barrels of cement per day, there would be a possible profit in the recovery of potash of between $100 and $200 per day.

---

[1] H. Seger and E. Cramer, in Thonind.-Zeit., 1904, Vol. 28, p. 531. See also Jour. Soc. Chem. Ind., June 30, 1904, p. 661.

[2] Potash as a By-Product of Cement Industry, Rock Products, Vol. XXI, July 17, 1918, p. 16.

At the meeting of the Association of American Portland Cement Manufacturers in the same year, Meade himself called attention to the fact that, approximately, one-half of the potash in the raw materials was volatilized in the burning of cement, and that the crust which collects on the walls of the kiln stack contained a considerable percentage of potassium sulphate.[1]

It does not appear that any attempts were made to recover the soluble potash from the stack dust or cement plants prior to the war. Standard practice consisted in returning this dust to the mix whenever it was collected.

In the manufacture of portland cement it is necessary to reduce both the raw materials and the finished clinker to a fine state of division by grinding. As a natural result, much dust escapes into the atmosphere in the vicinity of these plants, either from the mill buildings or through the stacks. In some localities this dust is found to be a nuisance. In certain areas in California where orange and lemon groves predominate it was claimed that escaping cement mill dust was injurious to the groves. In Southern California certain orange growers instituted suits against the cement plants and eventually succeeded in having them enjoined by the courts to prevent the escape of dust, if their operations were to be continued. These plants are located near Riverside and near Colton. The California Portland Cement Company at Colton attempted to eliminate the dust nuisance by installing large dust chambers into which the flue gases were led. The Riverside Portland Cement Company, at Riverside, interested themselves in the electrical precipitation methods, which were then being developed by Dr. F. G. Cottrell. The results of their experiments has finally led to the great development that has taken place within the last few years in the art of dust collecting by electrical precipitation. Soon after the installation, at Riverside, of the Cottrell system for collecting dust, it was noticed that this dust carried a rather high percentage of potash salts. When the supplies of European potash were cut off by the war, this dust became a saleable article. The amount of soluble potash present in the dust, as recovered, is not very large, and the desirability of producing soluble potash salts in a more concentrated form was quickly evident. Experiments were instituted by Huber and Reath[2] at the Riverside plant, and they succeeded in developing a satisfactory process.

The first installation at an American cement plant, erected primarily for the purpose of recovering the potash salts, is that of the Security Cement and Lime Company at Security, Md., not far from Hagerstown. This company installed the Cottrell system in 1916, and have since carried out a good many experiments. Their operations have been very successful, and much of the information that is available to cement manufacturers in America has been made public through the several articles published by their manager, Mr. John J. Porter. Much additional information has also been supplied through the Western Precipitation Company, of Los Angeles, which controls the patent rights of this system of precipitation.

---

[1] Richard K. Meade. Recent Developments in the Cement Industry, Chem. Met. Eng., Sept 27. 1918 p. 471. See also Chem. Eng., Vol. 2, 1905, p. 221.

[2] Potash from Cement at the Riverside Portland Cement Company, Met. Chem. Eng., June 15, 1917, pp. 701-3.

During the last two years there have been developed in the western states several systems for the recovery of the potash-bearing dust which use some form of water spray for cleaning the gases. These systems have been designed in the attempt to develop a process that will show a higher efficiency than that hitherto obtained by electrical precipitation alone, as applied to this purpose.

At the present time 19 cement plants are known to have installed equipment for the purpose of preventing the escape of flue dust. Seventeen of these plants were erected, or are in course of construction, for the purpose of recovering the potash in the dust. One of the remaining two disposes of its flue dust as a potash fertilizer to local trade during certain seasons of the year. The other installation is for dust collection only. In the United States there are nine electrical precipitation installations in cement plants. There is also one in Norway, one in Sweden, one in Spain, and one in Japan. There are six cement plants in the United States using five different systems of water spraying for the recovery of the flue dust.

TABLE II.

Cement Plants provided with Potash Recovery Equipment.

ELECTRICAL INSTALLATIONS.

Akticvolagt Emissions Institet, Skanör, Sweden.
Alpha Portland Cement Company, Cementon, N.Y.
Asano Portland Cement Company, Tokio, Japan.
Asland Portland Cement Company, Moucada, Spain.
Clinchfield Portland Cement Company, Kingsport, Tenn.
Copley Cement Manufacturing Company, Saylors, Pa.
Dalen Portland Cement Company, Brevig, Norway.
Dexter Portland Cement Company, Nazareth, Pa.
Ironton Portland Cement Company, Ironton, Ohio.
Newaygo Portland Cement Company, Newaygo, Mich.
Riverside Portland Cement Company, Riverside, Cal.
Security Cement and Lime Company, Security (near Hagerstown, Md.)
Universal Portland Cement Company, Buffington, Ind.

SPRAY SYSTEMS.

California Portland Cement Company, Colton, Cal.
Golden State Portland Cement Company, Oro Grande, Cal.
Ogden Portland Cement Company Bakers, Utah.
Portland Cement Company of Utah, Salt Lake City, Utah.
Santa Cruz Portland Cement Company, Davenport, Cal.
Southwestern Cement Company, Victorville, Cal.

NOTES ON THE CHEMISTRY OF THE PROCESS.

The raw materials used in the manufacture of portland cement are, usually, some form of limestone (or marl), and clay, or shale. These materials are pulverized separately to a very fine state of division, and are mixed in the proper proportion as determined by experience. They are then submitted to a high temperature in a special type of kiln. Heat is supplied by the combustion of some form of fuel. In eastern America, pulverized coal is almost invariably used. In certain of the western states, natural petroleums are employed. In a few plants natural gas is utilized for burning. At a temperature of about 700° C., the carbonates in the limestone are decomposed, with liberation of carbon dioxide, and the formation of lime. At temperatures of about 1430° C., the lime sinters with the silica and alumina of the clay or shale to form cement clinker. The sintered clinker after cooling is finally comminuted in special pulverizing machinery, and forms the cement of commerce.

The gases which pass through the stacks usually contain large or smaller quantities of the following products: water, in the form of steam derived from that present in the raw materials, or formed during the combustion of the fuels; carbon dioxide, liberated on the decomposition of the limestone, and formed during the complete combustion of the carbon element of the fuel; carbon monoxide, due to incomplete combustion; sulphur dioxide, formed from sulphur in the fuel, or liberated on the decomposition of gypsum present either in the raw mix or in the fuel; sulphur trioxide, formed from the dioxide by the catalytic action of dusts in the stack; nitrogen, derived from the air supplied for combustion; and occasionally a small excess of uncombined oxygen. The stack gases also contain the volatilized salts of a certain portion of the alkaline metals (sodium, potassium, and lithium) present in the original raw materials used, and considerable quantities of dust derived from the raw mix charged or from the fuel ash where coal is used.

In average practice it is found that about 608 pounds of dry raw mix are required to produce one barrel, or 380 pounds, of cement. (In Canada, 546 pounds of dry raw mix to produce one barrel, or 350 pounds, of cement.) About 100 pounds of coal having a heating value of 13,500 B. Th. U. are required to burn this material. Where petroleum is used as fuel, about 9·4 gallons, having a heating value of 18,800 B. Th. U. per pound, are required.

There are two principal methods of cement manufacture, usually termed the dry process, and the wet process. As the name indicates, in the dry process the raw mix is fed direct to the kilns in a dry state as it comes from the pulverizers. In the wet process the raw mix is ground with water to form a slurry. Slurry as fed to the kilns contains from 38 to about 45 per cent of water, which must first be evaporated before the burning process can begin. It is obvious, that owing to the presence of this large quantity of water, the temperature of the escaping flue gases, where the wet process is in use, will be lower than in the dry process.

The temperatures of the stack gases as they leave the kilns are usually about 800° C., in the dry process, and 150° C. in the wet. The maximum temperature in the zone of greatest heat is about 1430° C., occasionally slightly higher. The temperature of the clinker at the point of discharge is usually about 700° C.

As regards the by-products which are available in cement mill practice, approximately 13 per cent of the total heat generated is carried out of the kiln with the clinker. Occasionally, a portion of this heat is used for preheating the air supply. About 45 per cent of the heat is carried out of the kiln by the dust-laden flue gases, and approximately 10 per cent, or higher, is lost by radiation. In ordinary practice, about 480 pounds of carbon dioxide per barrel of cement escape with the flue gases, slightly less than one-half of this being dervied from the limestone in the cement mix. The quantity of potassium salts carried out with the flue dust and gases varies in ordinary practice from 2 to about 7 pounds per barrel of cement. Sodium and lithium oxides, liberated in association with potassium oxide and volatile salts of these metals, are also found in the flue dust and gases.

The salts of the alkaline metals which are found in the flue gases and dust, are derived from alkaline silicates present in the raw materials used in the cement manufacture. The greater portion of these is usually found in the clay or shale used in making the raw mix. Small amounts may be derived from the limestone, or from the ash of the coal used for fuel.

Analysis of the raw mix from Canadian plants shows a variation in potash content between 0·50 and 1·04 per cent. In the process of burning, the potash-carrying silicates are decomposed at the high temperatures, probably owing to reactions with the lime. There are present in the kiln gases, carbon dioxide, sulphur dioxide, and possibly other compounds. Consequently, the formation of a number of different alkaline salts is possible. The potassium salt which occurs in the largest amount is the sulphate. The thiosulphate, the sulphide, and the carbonate, also occur. Under certain conditions the odour of sulphuretted hydrogen can be noted in the escaping gases, and the elemental sulphur has been found on the walls of some of the treaters. The corresponding salts of sodium and lithium probably also occur.

Where petroleum is used as fuel, it has been found that a greater proportion of the potassium salts in the recovered dust is soluble than where the fuel used was coal. Further investigation showed that it was probable that in the latter case the silica from the ashes of the coal combined with the alkaline salts to form a silicate which was insoluble in cold water, but which was slowly soluble in hot water or in weak acid solution.

CEMENT MILL DUST RECOVERY.

General.—The methods employed for the recovery of the potash constituents volatilized in the process of cement manufacture, all depend upon the fact that these constituents are carried into and through the stack with the escaping flue gases. The problem, therefore, became one of cleaning these gases, recovering the solid products, and separating the potash salts from the less desirable residues. Two general methods have been developed, the one for cleaning the dry gases, the other in which the gases are cleaned by a system of water sprays."[1] During the course of development of the electrical precipitating process it was found that a large proportion of the volatilized potash salts were in such a condition that they were not easily removed from the gases. The development of the water spray systems on the one hand, and of the electrical water film treater on the other, marks further steps in the progress that has been made in attempts to increase the efficiency of potash collection methods.

---

[1] It is not considered necessary to discuss the bag-house system of dust collecting in connexion with cement mill practice.

Dry cleaning methods. Two types of equipment are in use: one, the expansion chamber, which is supplemented by a series of auxiliary chambers in which water sprays are located, and the other, electrical precipitation by the Cottrell system. This latter method may be further subdivided on the basis of the type of treater used.

(a) Expansion Chamber System.—The expansion chamber system was first introduced by Mr. T. J. Fleming at the plant of the California Portland Cement Company, near Colton. The following description of the dust-collecting system is based on an article published by W. C. Hanna.[1] This installation consists of two very large rectangular chambers, connected with the cement kiln stacks by long flues. Exhaust fans are used at the ends of the flues close to the expansion chamber. The draft for the kilns and driers is maintained by the suction of these fans. The fans discharge into the large dry settling chambers immediately adjacent. The area of the cross-section of these chambers is so large, in comparison with the area of the cross-section of the flues, that the velocity of the gases, and consequently their carrying power, is very greatly reduced. All the coarse dust and some of the fine dust settles. Incidentally, this dust is collected in a series of receptacles which deliver directly to screw conveyers, that collect the dust from different parts of the chamber, and deliver it to a central common conveyer, which in turn carries it to the dust-treating plant, or back to the cement mill. Beyond the dry dust settling chamber is another chamber which is subdivided by apron walls in such a way that all the escaping gases pass upwards and downwards seven times before reaching the outer air. During each of these seven passes they are subjected to the action of a fine water spray, which effectively removes the finer material that did not settle in the dry chamber. The liquors from these spray chambers are passed through a series of conical settlers, to remove the dust, the liquor being returned to circulation, or filtered and treated for the recovery of its potash content when it reaches the desired strength.

(b) Electrical Precipitation.—The principles applied for the removal of solid particles from flue gases in the Cottrell system of electrical precipitation, have been very frequently discussed since its first introduction, in 1910. The more important references to the subject are listed in the bibliography at the end of this bulletin. References are also given to descriptions of a number of installations, hence it is not necessary to discuss the subject here.

In the application of the Cottrell system to the precipitation of cement mill flue dust, two principal types of electrical treaters have been developed. In the one, the operations are carried on so that the dust is recovered in a dry state. In the second type, the dust is recovered as a sludge, and the soluble portion has for the most part gone into solution in the water.

With respect to those treaters in which the dust is recovered dry, there are two kinds, usually termed the " plate " treater and the " pipe " treater. An electrical treater of the plate type was the first developed for use in the cement business, and the Riverside plant is the only one in which they have been installed. There are eight installations in America, two in Scandinavia, one in Spain, and one in Japan, using the pipe type of treater.

---

[1] Hanna, W. C., The Fleming Dust-Collecting System, Met. and Chem. Eng., Sept. 15, 1915, p. 609.

In the plate type of treater a number of specially constructed collecting electrodes are arranged parallel, in a vertical position, and spaced at equal intervals, the whole being housed within a suitably constructed chamber. In the treater at Riverside, each plate consists of an angle-iron frame, on which a heavy metal screening has been stretched. Between each pair of electrodes is suspended a series of parallel vertical wires, suitably spaced, which act as discharge electrodes. The frame to which these wires is attached is insulated from the rest of the treater, and is connected with the negative terminal of the rectifier. The plates of the treater and the positive terminal of the rectifier, are both grounded. The treater housing is so constructed that the effluent gases from the flues pass between the plates of the treater in a horizontal direction.

A single unit of the pipe type of treater consists of a vertical pipe made of sheet steel, usually about 12 inches diameter, and 18 feet long. The high tension discharge electrode consists of a single wire, suspended vertically along the axial line of the pipe. The walls of the pipe act as the collecting electrode. The number of pipes in a treater unit vary according to circumstances from 80 to 240.

In operation, the gases to be cleaned enter the treater at the top, pass downward through the several pipes which constitute the unit, and are discharged into a common flue below. Occasionally, the path of the gases is reversed, being from bottom to top, instead of top to bottom. A special hopper bottom is provided below the treater unit, to receive the dust. This hopper usually discharges from below, either continuously to a conveyer, or intermittently to cars, barrows, or a stacking plant.

When in operation, the greater portion of the dust is deposited on the surface of the collecting electrodes. At stated intervals the stream of gases is interrupted, the gases being diverted to another treater, and the accumulated dust is shaken from the sides of the collecting electrodes, vibrations being generated by striking the pipes with suitably suspended knockers. The discharge electrodes are also shaken, to free them from any dust which may have collected upon them.

In practice, a battery of two or more unit treaters is generally employed in order that there may be no interruption in the current of gases discharged through the flues, though it is diverted from each treater in turn for the purpose of removing the accumulations of dust.

(c) Water Film Treater.—The discovery that a considerable portion of the volatilized potash salts remained in the gases after the heavier dust particles had been removed, made it necessary to institute experiments to develop some type of treater which would recover as much of this potash as possible. The film type of treater was devised for this purpose. This treater is so designed that, a thin film of water is maintained in constant flow down the faces of the collecting electrodes. In the form which was installed first at Security, each unit consists of 8 sections. Each section consists of a vertical cell about 14 inches wide, 18 feet long, and about 20 feet high. The walls between sections are about 8 inches thick, the whole unit being a concrete monolith. A water trough is provided at the top of the treater, and is so constructed that each section is completely encircled. The circulating liquid is conducted to the trough through suitable pipes, from which it overflows down the walls of the cell. It is kept in circulation by a centrifugal pump. When the treater is in operation, water is discharged from the troughs over each of the four walls of the section, so that a thin film covers the whole surface. The circulating liquid is collected in a suitable chamber below the treater, and after suitable treatment to remove the sludge which may have collected, it returns to the pump. The wires for carrying the high tension current are suspended from a frame connected with the negative pole of the rectifier. In each section of the treater the high tension wires are suspended along the median plane, equi-spaced with respect to each other, and with respect to the adjacent walls. In operation, the gases are admitted at the bottom of the treater, and pass out through the top.

The second type of water film treater combines the features of the dry plate treater and the sectional water film treater. The median walls of the sections are retained, and suitable equipment is provided to discharge a uniform water film over the whole of their working surface. No end walls are provided on the sections. The wires carrying the high tension current are suspended along the median plane between the section walls. The stream of gases enters at one side of the treater, and is discharged at the other.

A dry treater of the plate type, as already noted, was first installed in the plant of the Riverside Portland Cement Company, at Riverside, California, to treat the flue gases from ten kilns. More recently, a pipe treater was installed to take care of the effluent gases from an installation of two additional kilns. Pipe-type, dry treaters, have also been installed at all the other cement mills but one using this system, as shown in the accompanying schedule. A water film treater of the open section kind, in which the gases enter and are discharged laterally, has been installed in the plant of the Newaygo Portland Cement Company, Newaygo, Michigan.

Combinations of these two types of electrical treater, operating in series, are also being tried out experimentally. At Security, the hot gases as they come from the kilns, are first cooled by the admission of a certain quantity of air, and are then conducted through the pipe treater, where the greater portion of the dust particles are removed. From this treater they are conducted to the water film treater, for final treatment before discharge into the atmosphere. In the plant of the Clinchfield Portland Cement Company, at Kingsport, Tenn., it is proposed to treat the gases in much the same way as at Security. The pipe treater has already been installed, but the water film treater, which is to be of the plate-type, with side adits and exits, has not yet been erected.

SPRAY SYSTEMS.

General.—The following classification has been evolved for convenience in describing the various spray systems for cleaning the gases to recover the potash salts by the use of sprays and circulating solutions.

In the simplest type, sprays are introduced directly into the flues, and a special chamber is provided in which the escaping vapours are trapped by means of special tile, suitably arranged in towers. A coke tower, or a quartz tower, could be used for the same purposes. In another type we find flue spraying followed by a special condenser, in which a portion of the water vapour is recovered, containing more or less of potash salts in solution, and, incidentally, the waste heat available from the condensation of the vapour is used for the evaporation of a portion of the saline liquors. The second group of spray systems employ special chambers in which the flue gases are subjected to treatment with sprays. Usually, the chambers are arranged in series, the gases being subjected to treatment in three or four units, arranged in series, one after the other, before they escape. One type of spray chamber has been evolved in which the escaping gases, after saturation with water, are filtered through specially designed filter beds made of excelsior.

Supplementary operations. It is only under certain particularly favourable conditions that it is possible to market the flue dust containing the potash salts in the form in which it is collected through any one of the several types of the preliminary operations described above. It is usually necessary to subject the collected dust to some supplementary treatment for the purpose of concentrating the potash salts. It is obvious that these operations must be carried on in harmony with the other operations of the plant. Moreover, the flue gases from the cement kilns, escaping where the dry process is in use, are capable of supplying a considerable quantity of heat which can be recovered for utilization if the proper equipment is provided. About 45 per cent of the heat generated by the combustion of the fuel is lost through the flue gases.

A portion of the waste heat can be recovered through the installation of water tube boilers and preheaters. This is being done at the Cementon (New York) plant of the Alpha Portland Cement Company where an electrical treater of the pipe type is in operation. A similar installation is in operation at Nazareth, at the plant of the Dexter Portland Cement Company. In both cases the boiler equipment is installed close to the kilns, and a high speed fan has been placed in the system between the waste heat recovery equipment and the electrical treater.

The waste heat in the flue gases can also be utilized for the purpose of evaporating the water from the saline solutions which are circulated in the spray systems, or which are specially prepared in the dry recovery systems. Where waste heat is used for evaporating purposes, we find that special pans are sometimes placed over the top of the flues, or they may be so constructed that the bottom projects downward into the flue.

Saline solutions are prepared in the plants where dry dust is collected, by mixing the dust with water at a suitable temperature, usually about 85° C. The digestion operations are carried on in special tanks, and when completed, the liquors are drawn over into settling tanks, where the solids are permitted to settle, and the liquor is removed in a suitable manner. In the water spray systems, occasionally some of the dry dust which collects in the flue between the kilns and the first spray chamber is subjected to digestion treatment in hot water. After settling, the liquor is drawn off, and joins the liquor from the spray system. In both cases, the liquors to be evaporated, after final treatment in settling tanks, are passed through a filter; both Oliver and American filters being used for this purpose. It has been found that a saturation of about 3½ per cent soluble potash salts is the most satisfactory for the spray systems. If the percentage of potash salts present is permitted to become much higher than this, a proportion of the salt is likely to remain in the spray chamber. In plants where there is no liquor circulating system for spraying purposes, and where the only liquors to be treated are those made through the treatment of the dry dust, the soluble potash content of the liquor may be somewhat higher. After filtration, the liquors are collected in storage tanks, from whence they are conducted to the evaporating pans.

The final stages of the evaporation operation are sometimes carried on in separate equipment, with an independent source of heat. In some cases direct-fired pans are used for this purpose, in other cases specially constructed evaporators are utilized, to which the heat is supplied by the use of steam coils, and a special boiler. In the latter case, crystallizing pans are also used.

DESCRIPTIONS OF INSTALLATIONS

The following descriptions are included to provide the reader with a general understanding of the nature of typical installations. References will be found in the accompanying bibliography to more detailed published descriptions where such are available.

Riverside Portland Cement Company, Riverside, California. The treaters, at Riverside, are carried upon an elevated platform, about 80 feet above the ground. The original stacks were each provided with a short extension, which reaches above the roof of the treater building, the exit being controlled by a damper of special design. A complete electrical treater is placed on either side of each stack extension, with which they are connected. Special dampers placed between the stack and the treaters make it possible to control the movement of the stack gases. Gases can thus be discharged into the air, can be sent through either one of two treaters, or both treaters can be used in parallel. This design was developed to provide for temporary shut-downs, for any purpose, such as cleaning or repairs. Ordinarily, the gases pass through both treaters. The individual treaters have a cross-section of 12 by 16 feet, and a length in the direction in which the gases travel, of 20 feet. The electrodes are spaced 6 inches apart, there being 20 rows of discharge electrodes in series. The intervening collecting electrodes upon which the solids are deposited are of heavy construction, and so designed that, normally, no discharge takes place from their surfaces. Beyond the main treater a smaller auxiliary treater of the same type has been erected, to provide for the final cleaning of the gases.

A short stack extends about 20 feet beyond the last treater, to provide the necessary draft.

About 95 per cent of the dust collected is precipitated in the main treaters. Beneath each treater is a series of four hoppers. Experience has shown that the first dust collected contains only a very small amount of potash, whereas the finer dust collected in the last treater contains a considerable amount. In practice, therefore, the dust collected in the first two series of hoppers is usually returned to the raw mix. The dust collected in the last pair of hoppers under the main treaters, and that collected in the auxiliary treaters, is subjected to a digestion treatment, for the purpose of recovering the soluble potash. The residues, after digestion, are also returned to the raw mix.

The power required to operate a single treater is 7·5 kilowatts, including the power for all motors needed. This would be equivalent to about 15 kilowatts for a 1,000-barrel cement mill. It is to be noted that this system depends for its operation upon the natural draft, and that no fans are employed.[1]

Alpha Portland Cement Company, Cementon, N.Y.—At this plant an electrical precipitator of the pipe type is employed for cleaning the flue gases. This was installed primarily for the purpose of preventing the escape of the dust to the air during the winter season, since it was found that this dust marred the ice crop which is harvested nearby, from the Hudson river. At this plant a waste heat recovery system is installed and the dust collecting apparatus is only of secondary importance. In this installation the hot gases from all the kilns are conducted to a common flue, from which they are led through two water tube boiler installations, thence to fuel economizers, and thence to a fan which delivers into a common duct. This duct leads to a flue above the electrical precipitators, of which there are eight, arranged in two batteries, of four units each. Lateral ducts distribute the gases from the main flue to the treaters. The gases pass downward through the treaters, and thence horizontally through a short flue to a discharge fan, beyond which extends a short stack. Each treater consists of eighty pipes, 12 inches diameter, each 16 feet long. The dust collected is sold locally as a fertilizer during certain portions of the year, and is returned to the raw mix when there is no immediate market. Steel construction is used throughout, both for flues and treaters.

Dexter Portland Cement Company, Nazareth, Pa. At this plant the stack gases from the six kilns are collected in a common steel flue. From this flue they are led through two water-tube boilers, provided with superheaters and economizers. From the waste heat boilers the gases pass to a common high speed fan, placed immediately beyond the boilers, and connected with the distribution flue which supplies the treaters. The electrical precipitation equipment consists of five units, arranged in a single row 120 pipes to each unit. Parallel to the treater building is a concrete distributing and collecting double flue, the two parts being separated by a common median wall. From the top of this flue separate conduits lead to each treater. From the base of the treaters other conduits return the cleaned gases to the outlet portion of the flue. The outlet flue leads to a fan which delivers the gases to a short stack. The dust collected in the treaters falls into a series of hoppers, one beneath each treater; from hence it is delivered to a screw conveyer, which transfers it to the dust collecting building. Massive reinforced concrete construction is used in the treaters. The hoppers beneath the treaters are made of reinforced concrete and the distribution and outlet flues are also made of concrete.

Security Cement and Lime Company, Hagerstown, Md. This was the first company to install an equipment primarily for the purpose of recovering potash from its flue dust. Two types of treaters are in use, a dry pipe treater, and a water film treater. The dry treater is composed of three units, each unit containing 200 pipes, 12 inches diameter, and 20 feet long. Each unit is 20 feet wide, and 10 feet long. The wet treater also consists of three units, each unit having eight sections. Each treater cell in a section is about 14 inches wide, 18 feet long, and 20 feet high. A fan is placed in the circuit between the dry and water film treaters, so that both the kilns and the dry unit are under suction while the film treater is operated under pressure. The flue gases pass through the stacks to the dry treater, thence through the fan to the water film treater. They are delivered into the top of the dry treater, passed through the pipes, and are thence delivered into a common flue, located between the hoppers in which the dry dust is collected. From this flue they are led through the fan to the base of the water-film treater. They pass upward through the cells of this treater, and escape through a short stack at the top of the treater building. If desired, they can be discharged directly into the air, without first passing through the water-film treater.[1]

---

[1] Abstract from "The Control of Dust in Portland Cement Manufacture by the Cottrell Precipitation Process," Walter A. Schmidt, 8th International Congress of Applied Chemistry, Vol V, p 117

At this plant the potash in the raw mix ranges from 1·10 per cent to 1·30 per cent. The liberation originally secured was about 40 per cent, but this has been increased to an average of over 70 per cent, and as high as 85 per cent has been attained. Common salt is being employed for the purpose of increasing the liberation, the amount used being about three-fourths of one per cent. The efficiency of collection of the liberated potash varies between 60 per cent and 70 per cent. The actual efficiency, therefore, varies from 42 per cent to 59 per cent—an average of about 50 per cent. This efficiency has been attained only after close and careful experiment, and can be maintained only by careful operation.

Newaygo Portland Cement Company, Newaygo, Mich.—This plant is equipped with a water-film treater, built in three units. Each unit consists of eighteen pairs of collecting electrodes. The collecting surface of each electrode is about 7 feet wide, and 11 feet high. The electrodes are arranged in pairs facing each other, with a space of about 14 inches between each pair. The equi-spaced discharge electrodes are suspended in the median plane between each pair of collecting electrodes. Nine pairs of collecting electrodes are arranged in one block, and nine more in a second block; the blocks being set a short distance apart, and so built that corresponding pairs of collecting electrodes are in line with each other. These collecting electrodes are, in fact, concrete partitions, arranged parallel to each other, at equal intervals. A special, shallow reservoir, is provided in the top of each wall, into which the circulating liquor is discharged through a series of pipes connected with a storage tank and liquor circulating system. The liquor overflows from the reservoirs down each side of the wall, forming a film of liquid over the collecting surface of the treater. Special appliances are employed to secure an even flow. The gases to be treated pass through between pairs of electrodes horizontally, from one side to the other.

Since each collector consists of two independent parts, it becomes practicab'e to divide the collected dust into two parts, if necessary.

---

[1] For a more complete description consult "Recovery of Potash as a By-Product in the Manufacture of Portland Cement," Jno. J. Porter, Cement World, Chicago, Sept., 1917.
Also American Fertilizer, Aug. 31, 1918, p. 58.

The flue gases from the kilns are collected in a common flue, where the coarsest dust is dropped, enter the treater on one side, and are discharged on the opposite side into a common outlet flue, from which they pass to a fan that in turn delivers to a short stack. The sludge which collects at the bottom of the treater is transferred to a Dorr thickener, whence it is drawn off from time to time, and returned to the raw mix. The liquors are circulated over the collecting surface of the treater until they become charged with a certain amount of soluble potash salts. When of the proper density, the overflow from the Dorr thickener is pumped to an Oliver filter. The filter cake is returned to the raw mix, and the filtrate delivered to special evaporating pans arranged in series, with cascades between. Heat for the operation is supplied by direct firing beneath the pans. The potash salts, which crystallize out in the lower pans, are removed from time to time with a rake, and spread on a floor to drain and dry.[1]

Golden State Portland Cement Company, Oro Grande, Cal.— In this plant the flue gases are discharged directly into a small dry chamber, in which a certain quantity of the coarsest dust will be collected. From this chamber they pass into a flue, on the top of which three large evaporating pans have been placed, thence they pass into a series of three chambers, in two of which they come in contact with water sprays. From the spray chambers they pass into an expansion chamber provided with sprays. From the expansion chamber the gases pass into two large chambers specially arranged for collecting the water vapour. The collecting chambers beyond the fan, in the original plant, were provided with perforated, horizontal partitions, on which were assembled a number of tile. The interior construction was designed to cause the gases to travel by a staggered path, in such a way that they would come in contact with the tile surfaces at many points, to promote condensation of the vapours and absorption of the potash salts. The circulating liquors were collected in a common settling basin, and subjected to such treatment as was necessary for the purpose of removing the sludge. At stated intervals, when the liquor reaches the suitable concentration, it is run into the evaporating pans placed over the flue close to the dry chamber. The concentrated solution from the evaporating pans is further treated in special flat-bottomed oil-fired evaporators and finally in special crystallizing pans. This plant was stated to be making potassium nitrate by a special patented process.

Southwestern Portland Cement Company, Victorville, Cal. In this plant the flue gases pass through a long concrete flue, in which much of the coarse dust is deposited. From the end of the flue the efferent gases pass through a small flue to the spray chamber, where they are heavily sprayed with the circulating liquor. This chamber is about 30 feet long, and is equipped with 50 Demeral spray nozzles at the top and sides. From the spray chambers the moist gases pass through a special evaporator condenser, where the latent heat of the vapours is utilized for the purpose of evaporating the water from the liquors in a special type of evaporator. From the condenser they pass to the outer air. A fan is employed to regulate the circulation throughout the system. The dry dust collected in the main flue is being digested to recover the soluble potash and filtered.

---

[1] See Rock Products, June 7th, 1919, pp 29 31

The filtrate is added to the circulating liquors. From time to time, a portion of the circulating liquors are drawn off and delivered to the evaporating chamber of the condenser. When they reach a certain point of concentration they are transferred to a special crystallizing evaporator, which receives its heat from an independent supply.[1]

Portland Cement Company of Utah, Salt Lake City.[2]—In this plant the flue gases are delivered to a common flue in which the coarser dust is collected. From this flue they are led to two cyclone separators. Special flues and by-passes are provided, so that it is possible to deliver the gases from either of the cyclone separators to any one of the three sets of spray chambers. Each set of spray chambers contains four sections, arranged in series, and is termed the saturator. From the saturators the gases pass to two fans, each of which delivers to a condenser unit. A condenser unit consists of four separate chambers, of about the same size as the spray chambers, the last of which opens out directly into the atmosphere. The path of the gas, through the spray chambers and through the condenser, is alternately upward and downward. Beneath each series of spray chambers is a V-shaped trough, in which the circulating liquors collect. An apron below the walls of the spray chamber extends into the tank, so that the bottom of each chamber is water sealed. The spray liquors are circulated by a centrifugal pump. The dry dust collected in the main flue is treated in a digester to recover the soluble portion. The liquors pass through settling tanks, and are then filtered. After filtration, they are concentrated in special evaporators, and this is followed by treatment in crystallizing tanks. At this plant the spray chambers are built in a single block of four sections, in series, with common dividing walls between adjacent sections. The chambers are rectangular in cross-section, and the sprays are introduced in the angles near the top and in the centre of the chamber at the top. The condenser chambers are of similar construction, and are provided with sprays. The greater portion of the potash salts are recovered in the saturator unit, and only a very small amount in the condenser.

Ogden Portland Cement Company, Bakers, Utah.[3] The water spray system installed at this plant is similar to that installed in the plant of the Portland Cement Company of Utah, at Salt Lake City. The gases from the kilns are conducted through concrete flues to a main distributing flue—also of concrete. From the distributing flue two conduits lead to two saturators, each of which consists of a series of four spray chambers. From the saturator the gases pass through a sirocco fan to the condensing chamber, and thence to the discharge outlet. Each chamber of the saturator is of the silo type of construction, being made of separate concrete interlocking blocks, circular in cross-section, 18 feet diameter. Sprays are introduced at the top and sides. The circulating liquors are collected in troughs beneath the saturators, and the lower edge of the walls of each spray chamber is provided with an apron which dips below the surface of the liquor forming a water seal. When the liquors reach the proper degree of concentration, they are transferred to settling tanks, and the overflow is passed at intervals through Oliver filters. The filtrate is treated in a special evaporator in which the sodium chloride is first removed. After the greater portion of this chloride has been removed, the hot liquors from the evaporator are run into shallow rectangular concrete crystallizing tanks, in which the potash salts collect as the liquor cools.

---

[1] For a full description of this plant, refer to "The Wet Process for Extracting Potash from Cement Dust," J. G. Dean, Chem. and Met. Eng., Sept. 26, 1918, p. 439.

[2] Potash recovery plant, built from the designs of Messrs. Treanor, Huber, and Fisher, Riverside Portland Cement Company.

[3] Potash recovery plant built from designs of Messrs. Treanor, Huber, and Fisher, Riverside Portland Cement Company.

Santa Cruz Portland Cement Company, Santa Cruz, Cal.- In this plant the flue gases from the kilns are led through a scrubbing tower, where they are subjected to heavy water sprays which removes the greater portion of the dust. From the scrubbing tower they pass horizontally through an excelsior screen, which is kept moist, into a large chamber. This chamber is provided with two horizontal beds of excelsior which extend over its whole area. The lower bed is about 2 feet thick, and the upper 6 feet. Water sprays in the top of the chamber are used to moisten this material at intervals, and care is taken that it does not become too closely packed. A third excelsior filter is also placed beneath the outlet in the top of the chamber, the excelsior being moistened with water sprays as required. A fan, located at the discharge end, provides the necessary suction for the system. The circulating liquors are collected in a sump in which the solids accumulate. The mud and liquor are transferred by a diaphragm pump to an Oliver filter. The solids are returned to the cement mix. The liquor is delivered to an evaporator of special construction. This evaporator is a cement kiln which has been provided with a ribbed lining of wood throughout the greater portion of its length. The liquors are delivered at the upper end, and as the kiln slowly rotates they are lifted and dropped into the path of the hot gases which are generated by the blast of an oil burner at the lower end of the kiln. The rate of feed of the liquor is adjusted to the rate of evaporation, so that the dry salts are delivered at the lower end of the kiln.

CONDITIONS IN CANADA.

There are 9 corporations in Canada owning 21 mills for the production of cement. One of these firms uses blast furnace slag as a raw material, and another is producing a natural portland cement in vertical kilns. Omitting one mill which has been idle for some years and with respect to which no data are available, there are 18 mills, equipped with 109 cylindrical kilns, having a rated capacity of 46,000 barrels of cement per day. The sizes and capacities of the several kilns vary greatly; the shortest kiln reported is 60 feet long, while the longest measures 185 feet over all. (See Table III.)

TABLE III.

Cement Mills in Canada.

Operating Company	Process	Location of Plant	Raw Materials Used.	Kilns No	Kilns Diam	Kilns Length	Rated daily capacity
Alberta					*Feet.*	*Feet.*	*Barrels*
Canada Cement Co., Montreal, Que							
Alberta mill, No. 10	DC	Calgary	L and S	3	7½	100	1,500
Exshaw mill, No 12	DC	Exshaw	L and S	3 3	7 9½	80 150	3,000
Edmonton Cement Co., Edmonton	DC	Marlboro	L	1	8½	140	750
British Columbia							
British Columbia Cement Co., Victoria							
Bamberton mill	WO	Bamberton, V I	L and S	2	8½	185	2,000
Tod Inlet mill	WC	Tod Inlet, V I	L and C	1 2 1	8 7½ 9 9 10	125 155 170	3,000
Manitoba							
Commercial Cement Co., Winnipeg	DC	Babcock	Impure L	6	11	40 (vertical)	225
Canada Cement Co., Montreal, Que							
Tuxedo mill, No. 13	DC	Tuxedo	L and C	4	10	150	3,500
Nova Scotia							
Sydney Cement Co., Sydney		Sydney, C B	Blast furnace slag				140
Ontario							
Canada Cement Co., Montreal, Que							
Point Anne mill, No. 4	DC	Pointe Anne	L and C	8	7	60	1,800
Thurlow mill, No 5	DC	"	L and C	6	7½	125	2,700
Marlbank mill, No 6	WC	Marlbank	M and C	3 2 4	5 6 6	60 60 95	1,200
Lakefield mill, No. 7	WC	Lakefield	M and C	3 6	6 7	60 100	1,200
Port Colborne mill, No 8	DGC	Port Colborne	L and C	2 2	8½ 9½	150	3,000
Owen Sound mill, No. 9	WC	Shallow Lake	M and C	1 4	6 7	100	1,200
Ontario Portland Cement Co., Brantford[1]	WC	Blue Lake	M and C	4	6	70	500
National Portland Cement Co., Durham	WC	Durham	L and C	8	6	70	1,600
Hanover Portland Cement Co., Hanover	WC	Hanover	M and C	3	7	100	700
St. Mary's Cement, Ltd., Toronto	WC	St. Mary's	L and C	2	8	100	1,800
Quebec							
Canada Cement Co., Montreal, Que							
Montreal mill, No 1	DC	Montreal East	Impure L	4 4 9	8 8 9½	110 125 150	12,000
Montreal mill, No. 2	DC	Mercier ward, Montreal	"	4	7½	125	1,800
International mill, No 3	DC	Hull	"	10	7	60	2,800

NOTE D=Dry Process W=Wet Process C=Coal fired kilns O=Oil fired kilns. G=Gas fired kilns L=Limestone M=Marl S=Shale C=Clay

[1] In voluntary liquidation.

TABLE IV.

Potash Content of Cement Mill Materials.

Operating Company	Location	Process[8]	Rated Daily Capacity	Raw Mix Required for 350 lb. Bbl. Cement.	Potash in		Potash in Daily Run of		Daily Loss of Potash from Kilns.	Proportion of Total Potash Lost	Potash Lost per Bbl Cement	Estimated Potash in Flue Dust [7]
					Raw Mix.	Cement.	Raw Mix	Cement				
			Bbl.	Lb	Per cent.	Per cent.	Lb	Lb	Lb	Per cent	Per cent	Per cent.
Alberta—												
Canada Cement Co.,[1]	Exshaw	DC	3,000	550	0·70	0·69	11,550	7,245	4,305	37·3	1·43	6·5
British Columbia—												
British Columbia Cement Co.,[1]												
Bamberton mill,[1]	Bamberton, V.I	WO	2,000	546[6]	0·50	0·47	5,460	3,290	2,170	39·7	1·08	9·9
Tod Inlet mill[1]	Tod Inlet, V.I	WC	3,000	546[6]	0·53	0·44	8,682	4,620	4,062	46·8	1·35	12·1
Manitoba—												
Canada Cement Co[4]	Tuxedo	DC	3,500	580	0·72	0·69	14,616	8,453	6,163	42·1	1·76	7·6
Oatario—												
Canada Cement Co[5]	Thurlow (No. 5)	DC	2,700	585	0·91	0·85	14,372	8,033	6,339	44·1	2·34	10·3
Canada Cement Co[5]	Port Colborne	DC	3,000	565	0·79	0·61	13,391	6,405	6,986	50·6	2·33	10·3
Hanover Portland Cement Co[1]	Hanover	WC	700	546[6]	1·02	1·02	3,898	2,499	1,399	35·9	1·99	15·3
Ontario Portland Cement Co[1]	Blue Lake	WC	500	546[6]	0·68	0·40	1,856	700	1,156	62·2	2·31	21·1
St. Mary's Cement Co.[5]	St. Mary's	WC	1,800	550	0·74	0·90	7,326	5,670	1,656	22·6	0·92	8·4
Quebec—												
Canada Cement Co.[4]	Montreal East	DC	12,000	546	0·78	0·75	51,106	31,500	19,606	38·3	1·63	7·5

[1] Analysis by United States Department of Agriculture [3] Analysis by Mines Branch Laboratories [4] Analysis by J. T. Donald Laboratories, Montreal [5] Analysis by Operating Company's Laboratories. [6] Assumed quantity. [7] Assume 4 per cent dust loss in dry process, and 2 per cent in wet [8] D = Dry process W = Wet process C = Coal for fuel. O = Oil for fuel

In 1917 and 1918, there were only 10 mills in operation. The total amount of cement manufactured in 1917 is placed at 4,987,255 barrels, which includes 1,034 barrels of reclaimed cement. In 1918, the production was 3,417,660 barrels. In this connexion it is well to note that the Canadian barrel contains 350 pounds of cement; while the standard cement barrel in the United States holds 380 pounds.

During the course of this investigation inquiries were sent to fifteen Canadian firms engaged in the cement business, including certain firms not now manufacturing. Only six replies were received. Four firms, which were operating during the last two years, did not acknowledge the receipt of the inquiry, hence did not furnish any information.

Analyses of cement mill materials from a number of Canadian cement plants have been secured from various sources, since it was impossible to arrange for a complete investigation in the laboratories of the Mines Branch. This information has been utilized in the compilation of Table IV.

It will be noted that a number of the analyses are derived from United States sources, because no Canadian returns were available. The form employed for this table has been adopted from Table I, in Bulletin 572, issued by the United States Department of Agriculture. Owing to the difference between the Canadian and United States barrel of cement, it has been necessary to re-calculate a number of the items. The method of calculation is thus set forth in this bulletin.[1]

> "The values given in Table I for the potash contained in the daily production of cement were obtained by multiplying the output in barrels by the weight of one barrel 380 pounds[2]) and by the percentage of potash in the cement as found by analysis. To obtain the corresponding values for the potash in the daily run of raw mix, the output of cement expressed in barrels was multiplied by the weight of raw mix required per barrel of cement, and then by the percentage of potash in the raw mix. The difference between the two values, as thus determined, represents the potash that escapes daily from the kilns."

In the United States investigation it was found that the amount of potash lost per barrel of cement produced, varies from 0·35 to 5·14 pounds of K_2O. The average for 99 plants was 2·09 pounds per barrel, and the average for 9 Canadian plants was 1·95 pounds.

It is to be noted further that the information given in this table is based on rated capacities of the individual plants, not on the actual output. Information with respect to the output of individual plants is considered confidential. On the basis of the data given in this table, and on the basis of the actual output of individual plants, it may be stated that, in 1917 there were lost from our cement mills about 4,280 tons of potash, and in 1918, 2,700 tons; at least 60 per cent of which could have been recovered by known processes. The average market price for potash in the United States in 1917 was $4.26 per unit of 20 pounds, and in 1918 it was about $2.50 per unit.[3] The monetary value of the recoverable potash lost was therefore about $1,093,900 in 1917, and $405,000 in 1918. It should be noted further, that the output of potash from the kilns could have been very much increased without injury to the cement by the use of properly selected materials, and by the application of certain improved processes; so that the market value of the recoverable potash could have been raised nearly 50 per cent. These amounts do not represent profits which might have been recovered, because allowance must be made for the cost of recovery—including cost of experimental work, and cost of marketing. It is quite easy to be wise after the event, and to perceive an opportunity lost. Therefore the failure to recognize and to take advantage of this opportunity, now past, is not a proper subject for criticism. Before 1917, little was known about the processes for recovering potash from cement mill flue dust, and the future of the market, particularly the continuation of high prices, was very uncertain. Those firms in the United States who were willing to assume the necessary risks found their venture very profitable. A number of them have now in stock a large supply of clinker ready for grinding which has been paid for by potash sales, and they therefore find themselves in a very favourable position to handle new cement business, particularly export trade. On the other hand the firms who delayed investigating these processes and delayed installations have lost the high markets. In several instances, however, the potash recovery equipment was needed for dust recovery in any event. In most cases there is a strong probability that the potash can be recovered at a cost which will make it profitable to market it at normal prices without loss, or even at a small profit.

---

[1] U.S. Department of Agriculture, Bulletin 572, by Ross, Merz, and Wagner. The Recovery of Potash as a By-Product in the Cement Industry, p. 8

[2] The Canadian barrel of cement contains 350 pounds.

[3] Prices in 1918 fluctuated between $3 per unit in January to about $1 50 per unit, with no demand in December. No official data giving average market quotation for the year are available.

It is to be noted that any profit that accrues from the recovery of by-products over and above the cost of recovery can be applied to the reduction of the cost of producing cement, thus affecting the price of cement in competitive markets. This is a feature of the cement business that is well worth the attention of those Canadian cement manufacturers who hope to compete for foreign orders. The utilization of waste heat to reduce power costs, and even the utilization of waste carbon dioxide, are also worthy of more attention than has been given to them in the past.

FUTURE MARKET PRICES.

The United States War Trade Board announced on January 24th last, that it had received authentic and official information from the French High Commission in the United States that France would be unable to ship potash from the mines of Alsace until April. The entire output of these mines for the first few months of the year was urgently needed in France for agricultural purposes. It was therefore inferred that no Alsatian potash would be available in America before June.

According to "Rock Products,"[1] Alsatian potash prices are to be below pre-war German prices. These prices are listed as follows:—

---

[1] Rock Products, April 12, 1919, p 45

Alsatian Potash Prices.

	Per cent K_2O	German Syndicate's list prices F.O.B. Mines Per Net Ton	French Prices per net ton Jan. 5, 1919	German Pre-war prices per Unit in Cents	French Present prices per Unit in Cents
		$ cts	$ cts		
Kainite	12.5	4.76	4.51	38	36
Muriate	50.0	32.10	32.83	64.2	65.6
Manure salts	21·1	10.51	9.80	49·8	46.4

Orders for Alsatian potash, in car load lots only, are to be filed with the Central Office of Agricultural Chemical Products, 42 Rue de Bourgogne, Paris, from which they will be transmitted to the recently organized Bureau of Sales at Mulhausen.

PROTECTION FOR POTASH PRODUCERS IN THE UNITED STATES.

In the United States it is proposed to control imports of potash by a licensing system. A bill has been drawn up with this in view for the purpose of safeguarding the interests of the domestic producers until such time as trade conditions are re-adjusted. The following two sections of this bill are of interest:

Section 1. "Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, that, inasmuch as it is important for the national welfare and security to provide for an adequate and permanent supply of potash, and for this purpose to encourage the domestic production, manufacture, and recovery of potash, the Secretary of the Interior is hereby authorized and empowered to issue licenses from time to time, to persons, firms, or corporations, for the importation of potash, and from and after 30 days after the approval of this act no potash shall be imported into the United States without such license. Each license shall state the amount of potash which the licensee shall be permitted to import and shall be issued only on condition that the applicant has purchased or contracted, under guarantee satisfactory to the Secretary of the Interior, to purchase an amount of potash produced in the United States bearing the same ratio to the amount which he is permitted to import as the estimated total production of potash in the United States bears to the difference between this estimated total production and the estimated total requirements of the United States. Estimates of the total requirements and of the total production in the United States shall be made under the direction of the Secretary of the Interior at intervals of not less than six months, and as so made shall be taken as conclusive: Provided, That potash once reckoned in any transaction shall not be reckoned again: Provided further, That whenever the Secretary of the Interior shall find that potash is not being produced, or is not likely to be produced, in time or at a cost to make it economically available in the United States in sufficient quantities to meet the requirements as estimated by him, or whenever he shall find that the price thereof is not fair and reasonable, he may issue licenses for the importation of potash in excess of the proportion fixed under this section."

Section 2. Provides an appropriation of $150,000 to carry out the terms of the bill.

Section 3. "That five years after the proclamation of peace this act shall cease to be effective, all powers conferred thereby shall end, and the Secretary of the Interior shall terminate all transactions under this act."

COSTS OF POTASH RECOVERY.

It is not possible to furnish any very close general estimate of the cost of installing or operating potash recovery equipment at a cement mill. It is obvious that the cost of installation will vary according to local conditions; the type of construction employed; and the particular process selected. With the exception of the installations at Riverside and Colton, California, the several plants mentioned in previous paragraphs were built under war time conditions, and were to a considerable extent, experimental. The costs of construction and development in pioneer work naturally were higher than they would be under normal conditions.

Equipment costs.—A complete potash recovery plant, using the dry electrical precipitation method, would probably cost about $30 per barrel of daily cement capacity, if constructed largely of reinforced concrete, or concrete and tile brick. If all steel construction, the cost would be about double. A water film treater would cost in the neighbourhood of $25 per barrel of daily cement capacity.

A complete potash recovery plant using one of the water spray systems would cost from $30 to about $50 per barrel of daily cement capacity. The efficiency of this type of apparatus is higher, hence, the cost of the plant, on the basis of the potash recovered, would be lower.

A leaching and evaporating plant to produce concentrated salts for shipping, would cost in the neighbourhood of $25,000, if designed to treat the dry dust from a 3,000 barrel mill. If this plant were designed and constructed in connexion with a treater where saline solutions are circulated as part of the system for recovering the potash, the cost of such additional equipment as would then be required would be less.

In designing a potash recovery plant, it is to be noted further, that normally about 45 per cent of the heat generated by the combustion of the fuel used is lost with the flue gases and dust. Under favourable circumstances, a portion of this heat can be converted into power by the use of water tube boilers, super-heaters, and pre-heaters. The heat can also be utilized to evaporate the excess liquor from saline solutions. It would, therefore, seem to be expedient to design by-product recovery equipment in such a way as to utilize the waste heat as well as to recover the potash in a form most suitable for merchandising.

Operating costs.—The operating cost at the plant of the Security Cement and Lime Company in 1917 is given by John J. Porter, the manager, as follows[1]:-

Labour	$27	per day	= $0·0090	per bbl. clinker.	
Power	25	" "	= 0·0083	"	"
Repairs	8	" "	= 0·0027	"	"
Laboratory	120	" month	= 0·0014	"	"
Total			0·0434		

The cost of the salt addition was $0·0220 per barrel of clinker. The capacity of this plant is 3,000 barrels per day.

---

[1] Porter, John J., "The Recovery of Potash as a By-Product in the Manufacture of Portland Cement," American Fertilizer, Aug. 31st, 1918, pp. 58–72.

R. K. Meade has published the following estimates for a 3,000-barrel plant using a dry electrical treater[1]:

Labour and superintendence	$25	per day
Power at 1c. per k.w.h.	13	"
Repairs	10	"
	$48	

The addition of salt to the mix is stated to represent an additional cost of $70 or $0.025 per bbl. of capacity. The production of concentrated salts would entail an additional expenditure of $8 to $10 per day for labour, and $15 to $25 for power, and evaporating excess water. The latter expense can be reduced or eliminated by utilization of waste heat from the kilns.

Meade thus estimates the cost of operating a wet treater, applicable either to the water film electrical precipitator or to a spray system:

Labour	$35	per day
Power at 1c. per k.w.h.	25	"
Repairs	5	"
Fuel and evaporation	15	"
	$80	"

If salt is added the additional expense would be $70 per day, or 0·025 cents per barrel of capacity.

In estimating the costs of production for any given cement plant the potash recovery plant should be credited with the value of the leached dust returned to the raw mix as slurry; and with the saving of coal that is almost sure to result with the installation of fans, whereby the draft on the kilns and the cement burning can be more closely regulated. Porter[2] states that at Security the fuel consumption for 5 months in 1916, before the installation of the potash plant, averaged 96·4 pounds of coal per barrel; while for five months in 1917, with the potash plant, it averaged 87·0 pounds per barrel.

It might also be well to draw attention to the fact that the installation of potash recovery equipment does not involve any changes in the process of cement manufacture, and does not injure the product. On the contrary, the maintenance of more uniform burning conditions in the kilns under forced draft, is likely to result in a more uniform product.

CONCLUSIONS.

The problem of by-product recovery is one which should receive the serious attention of all Canadian cement manufacturers. It is obvious that the mill which can produce cement at the lowest cost will be in the most favourable position with respect to competitive business. All credits obtained from by-products, after allowing for amortization and cost of operating recovery equipment, can be applied to the reduction of the cost of cement manufacture. The ability to produce cement at a price per barrel only a few cents lower than a competitor might often be the means of securing valuable contracts. Where standard prices prevail slight differences in cost per barrel may add very considerable sums to the legitimate profits of the business during a year's operations.

---

[1] Meade, R. K., "Potash as a By-Product of Cement Industry," Rock Products, Sept 25, 1918, p. 25

[2] Porter, John J., Cement World, Chicago, Sept., 1917

While this report deals primarily with the subject of potash recovery, attention may also be turned in certain other directions in which economies can be effected.

Cement mill dust is very frequently a cause of trouble with the owners of adjacent properties, particularly in agricultural districts. It is also injurious to the workers in the mills. Anything that can be done to reduce the dust nuisance is therefore advantageous to both the mill owner, to his employees, and to his neighbours. All recovered dust can be returned to the cement mix. Its value represents a credit for the recovery plant, while the cost of recovery is a legitimate charge against cement manufacture in those mills where it is compulsory to prevent the escape of dust.

Fuel is one of the principal items of cost in operating a cement plant, and power costs are of equal importance. Many Canadian cement mills utilize imported fuels. It therefore appears desirable to reduce fuel costs to a minimum by utilizing the heat produced by fuel combustion as completely as possible. Those cement mills which are operating on the dry burning process may find it materially to their advantage to install waste heat recovery equipment for the purpose of reducing their power costs.

Potash recovery, fuel economy, elimination of the dust nuisance, reduction of power costs, and more complete utilization of waste heat, with the consequent reduction of coal consumption and coal imports, are all closely related problems that merit careful study.

BIBLIOGRAPHY.

Electrostatic Precipitation.

1. Bradley, L., Electrical precipitation of suspended particles by the Cottrell process Jour. Ind. & Eng. Chem., Vol. 4, No. 12, Dec., 1912.
2. Bush, H. J., Cottrell electrostatic recovery process of flue dust and fumes: Jour. Soc. Chem. Ind., Vol. 37, No. 20, Oct. 31, 1918, pp. 389R-91.
3. Bush, H. J., Cottrell process of flue dust recovery: Iron & Coal Tr. Rev., Vol. 97, Dec. 27, 1918, p. 728.
4. Cottrell, F. G., Electrical precipitation of suspended particles: Jour. Ind. & Eng. Chem., Vol. 3, No. 8, Aug., 1911, pp. 542-60.
5. Cottrell, F. G., Electrical fume-precipitation: Trans. A.I.M.E., 1912, pp. 667-680.
6. Cottrell, F. G., Recent progress in electrical smoke precipitation: Second Pan-American Scientific Congress, Washington, 1917. Contains bibliography.
7. Cottrell, plant, Westinghouse electrical equipment for: Eng. & Min. Jour., Vol. 106, Dec. 14, 1918, p. 1030.
8. Eschholz, O. H., Electrostatic precipitation: Trans. A.I.M.E., Sept., 1918, pp. 1293-1306, and Discussion pp. 1553-57. Gives selected bibliography. See also discussion by B. L. Sackett, Iron & Coal Trade Review, Vol. 98, Jan. 10, 1919, p. 49.
9. Rathbun, R. B., Electrostatic precipitation: Min. & Sci. Press, Vol. 118, Jan. 4, 1919, p. 22.

Potash Recovery at Cement Plants.

10 Agriculture, Department of, Washington, Recovery of potash as a by-product in the cement industry, by Ross, Merz, and Wagner: Bulletin No 572, Oct. 5, 1917
11 Bradley, L., Cottrell process for potash recovery: Chem. & Met. Eng, Vol. 19, Sept 26, 1918, pp. 457-60. See also Blast Fur. & Steel Plant, Vol 6, Nov., 1918, pp. 457-9
12 Bradley, L., Recovery of potash from iron blast furnaces and cement kilns by electrical precipitation: Jour. Ind. & Eng. Chem., Vol. 10, No. 10, Oct., 1918, pp 834-37. See also Iron Age, Vol. 102, Nov. 7, 1918, pp. 1151-3.
13 Clinchfield plant, Large potash recovery at: Manufacturers Record, May 2, 1918
14 Dean, J. G., Wet process for extracting potash from cement dust: Chem. & Met Eng., Vol. 19, Sept. 26, 1918, pp. 439-47.
15 Erdahl, B. F., Concentration of potash from raw materials containing only a trace of this element by means of the electric precipitation of flue dust and fume cement kilns: Jour. Ind & Eng. Chem., Vol. 10, May, 1918, pp. 356-9
16 Fleming, T. J., Cement company recovers kiln dust to prevent damage to orange crops; Engineering Record, Vol. 69, Jan. 6, 1914, pp. 640-1
17. Grasty, J. S., Potash as a by-product: Chem. & Met. Eng., Vol. 19, Sept. 26, 1918, pp. 431-8. See also Mfrs. Record, Sept. 19, 1918. Discussion, Gellert, N. H., Chem. & Met. Eng., Vol. 20, Apr. 1, 1919, pp. 308-9; Grasty, J S., Vol. 20, April 15, 1919, pp. 373-4
18. Hanna, W. C., Fleming dust catching system: Met. & Chem. Eng, Vol. 13, No. 10 Sept. 15, 1915, pp. 609-612
19 Iron Age—Blast furnace and cement kiln potash—Vol. 102, Nov. 14, 1918, p. 1299
20 Meade, Richard K., Potash as a by-product of cement industry: Rock Products, Vol. 21, 1918, July 17, pp. 16-19; July 31, pp 21-24; Aug. 14, pp 29-32; Aug 28, pp. 23-25; Sept. 25, p. 25
21. Meade, R. K., Recent developments in the cement industry: Chem & Met Eng, Vol. 19, No. 6d, Sept. 27, 1918, pp. 471-4
22 Porter, John J., Recovery of potash as a by-product in the manufacture of Portland cement: Cement World, Chicago, Sept., 1917. See also under same title, American Fertilizer, Aug. 31, 1918, pp. 58-72
23. Potash from cement mills—Review—Met. & Chem. Eng., Vol. 16, June 1, 1917, p. 653.
24. Potash resources, development of domestic: Eng. & Min. Jour, Vol 106, Aug. 17, 1918, p. 313.
25. Schmidt, Walter A., Control of dust in Portland cement manufacture by the Cottrell precipitation process: Eighth Internat. Cong. Applied Chem., Vol. V, pp. 117-24 See also Jour. Ind. & Eng. Chem., 1912, Vol. 4, p. 719
26 Treanor, John, Potash from cement at the Riverside Portland Cement Company: Chem. & Met. Eng, Vol. 16, June 15th, 1917, pp. 791-3
27. Treanor, John, Experience of the Riverside Portland Cement Company in the recovery of potash from cement flue dust. Reprint of paper read at annual meeting of the Portland Cement Association, Dec. 11, 1917
28 Treanor, John, Reprint Letter to J. W. Kittrell, Chairman, Committee on Conservation, Portland Cement Association, Sept. 19, 1918

Chemistry of Potash Liberation at Cement Mills.

29. Anderson, E., Double salts of calcium and potassium and their occurrence in leaching cement mill flue dust: Jour. Ind. & Eng. Chem., Vol. 11, No. 4, Aug. 1919, pp 327-32.
30. Anderson, E., and Nestell, R. J., Volatilization of potash from cement materials. Jour. Ind. & Eng. Chem., Vol. 9, No. 3, March, 1917, p. 253
31. Anderson, E. (See No. 39, Nestell, R. J., and Anderson, E.)
32. Bassett, H. P., Separation of potash salts: Chem. & Met. Eng., Vol. 20, No. 2, Jan 15, 1919, pp. 76–77.
33 Cheesman, R. D. (See No. 40, Potter, N. S., and Cheesman, R. D.,
34. Hanna, W. C., Mechanical precipitation and waste heat recover potash: Concrete, Vol. 12, sup., April, 1918, pp. 33-5.

35. Merz, A. R. (See No. 41, Ross, W. H., and Merz, A. R.)
36. Merz, A. R., Direct heat treatment of cement mill dust to increase its water-solubl potash content: Jour. Ind. & Eng. Chem., Vol. 10, Feb., 1918, pp. 106–9.
37. Merz, A. R., and Ross, W. H., Nature of the recombined potash in cement mi dust: Jour. Ind. & Eng. Chem., Vol. 11, No. 1, Jan., 1919, pp. 39–45.
38. Nestell, R. J. (See No. 30, Anderson, E., and Nestell, R. J.)
39. Nestell, R. J., and Anderson, E., Nature of cement mill potash: Jour. Ind. & Eng Chem., Vol. 9, No. 7, July, 1917, pp. 646–57.
40. Potter, N. S., and Cheesman, R. D., Effect of coal ash on the liberation and natur of cement mill potash: Jour. Ind. & Eng. Chem., Vol. 10, Feb., 1918, pp. 109–11
41. Ross, W. H., and Merz, A. R., Recovery of water-soluble potash as a by-product in the cement industry: Jour. Ind. & Eng. Chem., Vol. 9, No. 11, Nov., 1917, pp. 1035–43.
42. Ross, W. H. (See No. 37, Merz, A. R., and Ross, W. H.)

General References.

43. Stockett, A. W., Potash situation: U.S. Bureau of Mines, War Minerals Investigation Series, No. 2, 1918. See also, Jour. Ind. & Eng. Chem., Vol. 10, No. 11, Nov., 1918, pp. 918–20.
44. Stockett, A. W., Future of potash production as a rock products industry: Rock Products, Jan. 15, 1919, pp. 57–58.
45. War Industries Board, Methods of extracting potash in the United States: Jour. Ind. & Eng. Chem., Vol. 11, No. 1, Jan., 1919, p. 75.

Bibliographies.

46. Brückmiller, F. W., Potash industry literature 1912–1917: Chem. & Met. Eng., Vol. 19, Sept. 26, 1918, pp. 447–9.
47. Buck, E. C., Bibliography on the extraction of potash from complex minerals—feldspar, leucite, etc.: Met. & Chem. Eng., Jan. 1, 1918.
48. Gale, H. S., and Hicks, W. B., Potash in 1917: U.S. Geological Survey. Includes a list of patents and an extensive bibliography.
49. Potash bibliography: Jour. Ind. & Eng. Chem., Vol. 10, No. 10, Oct., 1918, pp. 837–8.
50. Consult also numbers 6 and 8 above.

ater-solluble
-9.
ement mill

nd. & Eng.

and nature
pp. 109–11.
py-product
Nov., 1917,

restigation
11, Nov.,

try: Rock

tes: Jour.

et. Eng.,

inerals—

ncludes a

p. 837–8.

PLATE I.

Electrical Treater Reinforced Concrete Construction, Dexter Portland Cement Company, Nazareth, Pa., U.S.A.

a Electrical treater [illegible]
b Generator [illegible] building
c Flues [illegible]
d Waste heat boilers
e Stack [illegible]

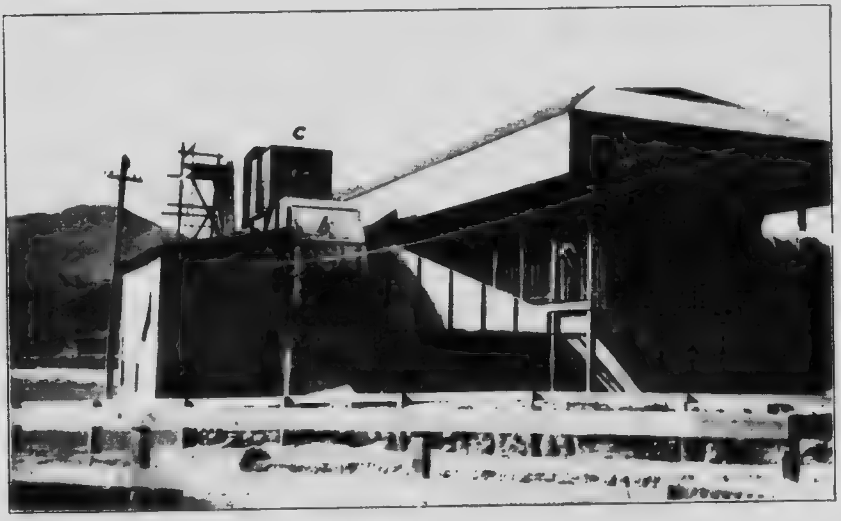
PLATE II

Electrical Treater Dexter Portland Cement Company, Nazareth, Pa., U.S.A.

a Distributing flue [illegible]
b [illegible]
c Waste [illegible]

62 42 4

PLATE III.



Pipe Type Dry Electrical Treater, Riverside Portland Cement Company, Riverside California, U.S.A.

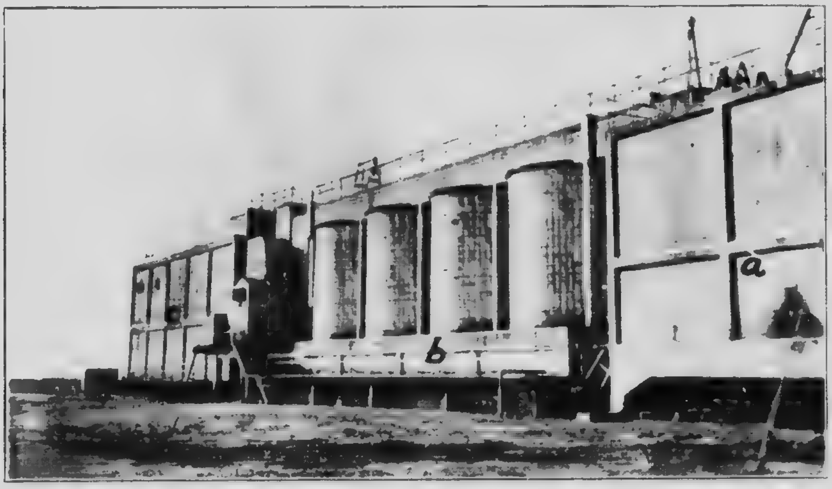
(a) Steel flue
(b) Fan housing
(c) Discharge stack

PLATE IV.

Treater Building and Stacks: Reinforced Concrete Construction, Newaygo Portland Cement Company, Newaygo, Michigan, U.S.A.

(a) Concrete stack and flue.
(b) Treater building.

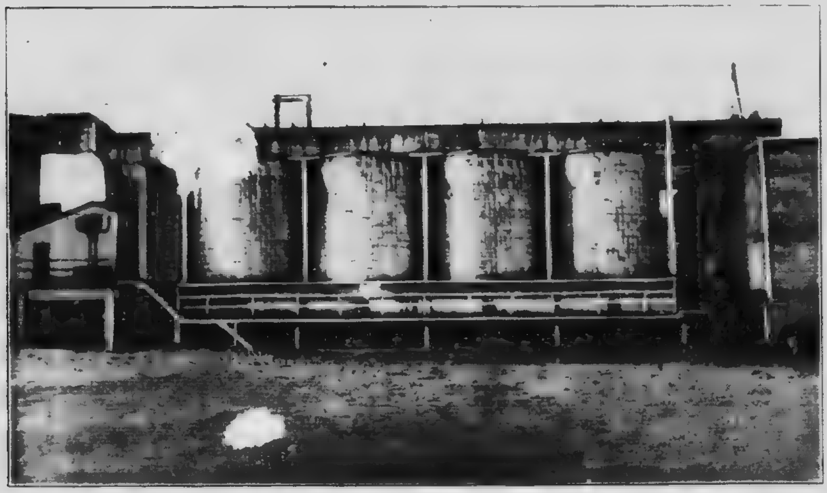
PLATE V.



Treating Plant, employing Spraying System: Reinforced Concrete Construction, Ogden Portland Cement Company, Bakers, Utah, U.S.A.

a) Distributing chamber
b) Saturator Tile block construction
c) Condenser

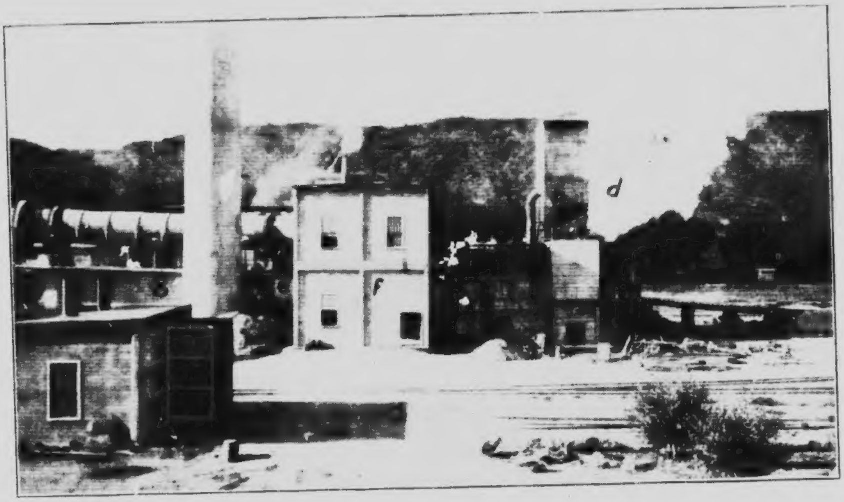
PLATE VI.



Treating Plant employing Spray System, Ogden Portland Cement Company, Bakers, Utah, U.S.A.

Saturator: consisting of four silos, tile block construction.
Fan housing on left

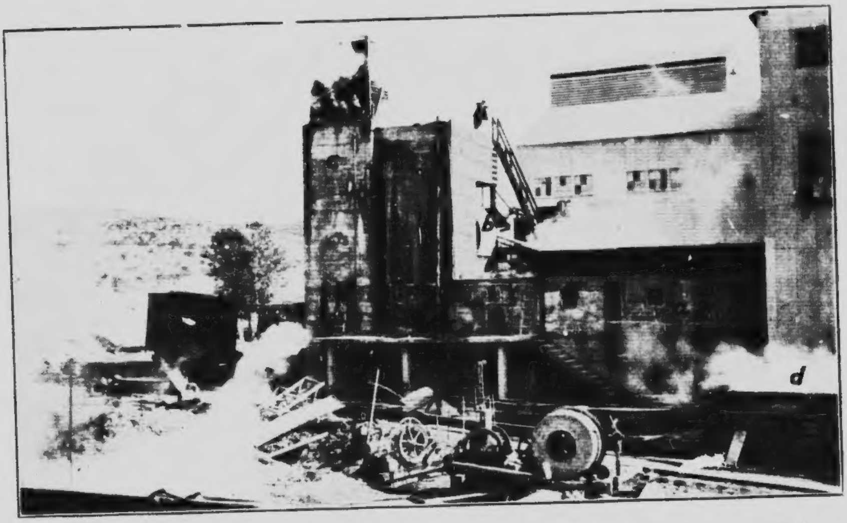
Plate VII.



Spray Treater and Condenser: Reinforced Concrete Construction, South-Western Portland Cement Co., Ltd., Victorville, Cal., U.S.A.

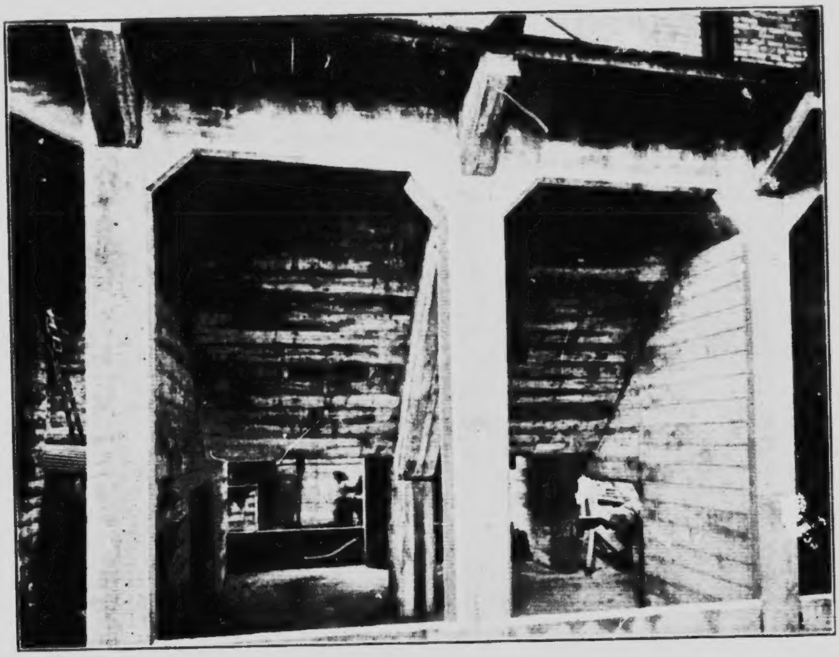
(a) Spray chambers.
(b) Evaporator condenser.
(c) Conduit leading to exhaust pipe.
(d) Fan housing.
(e) Flue leading to treater.
(f) Burner building.
(g) Main flue.

Plate VIII.



Spray Treater, Golden State Portland Cement Co., Oro Grande, California, U.S.A.

(a) Spray chambers, with evaporating tank on top.
(b) Fan housing.
(c) Tile tower.
(d) Pan evaporators.
(e) Crystallizing tanks.



Reinforced concrete sub-structure below saturator, showing bottom of trough in which circulating liquors are collected. Portland Cement Co. of Utah, Salt Lake City, Utah, U.S.A.

Sub-structure of saturator, concrete columns and beams. Portland Cement Co. of Utah, Salt Lake City, Utah, U.S.A.